IMAGE PROCESSING METHOD AND PROGRAM

BACKGROUND OF THE INVENTION

Field of the Invention

The present invention relates to a preparation of a look-up table for converting an input color signal into a plurality of color components including a black component.

Related Background Art

In order to form a device dependent C (cyan) M (magenta) Y (yellow) K (black) output value from an input R (red) G (green) B (blue) value from an application, it is known that a color printing apparatus is provided with means for converting the input RGB signal value into a device dependent RGB value and a color conversion LUT for converting the device dependent RGB value into the CMYK output value.

The decision of a K ink amount and an under color removal amount in each lattice point of the color conversion LUT have been calculated from a function with the minimum value of each CMY or K ink amount taken as a parameter. It is difficult to prepare a function for adequately controlling the K ink amount and, depending on a under color removal function, a graininess may have been often produced in an output of high lightness with a result that the image quality of an output image has been deteriorated.

Further, in the under color removal function and a method for preparing the color conversion LUT by a masking calculation method and also a method for performing a three dimensional interpolation in a L*a*b* color space from a three dimensional printer model and for searching a desired CMYK ink amount, not only a vast amount of calculation times have been required, but also an irregularity of gradation has been produced in an output result. Furthermore, with these methods, it cannot always be said that an output color space in the color printing apparatus has been reproduced up to a maximum and that sufficient color reproduction has been maintained for the RGB signal color space which is the input signal.

When the maximum density of the K ink itself is thin, in case of placing the maximum output value of the K ink only on a process black, an output density by a combination of three ink systems to be complementary colors for the adjacent chromatic color color ink, the K ink and the chromatic color color ink is higher than the process ink, and this often gives a rise to the problem and the like that a distortion is produced in the output color space for the color printing apparatus and that a quasi contour is produced in the output image.

SUMMARY OF THE INVENTION

It is a first object of the present invention to make it possible to obtain an output image of high quality which does not produce a graininess.

A first aspect of the present invention is an

5   image processing method for controlling a starting point for producing the black component between vertices showing a plurality of chromatic colors and a vertex showing a black in reproducible color space of a color output apparatus when a look-up table for

10   converting an input signal into a plurality of color components including a black component is prepared, wherein the starting point for producing the above described black component is controlled based on a complementary color component corresponding to the

15   chromatic color in which the graininess of a black recording material is inconspicuous in the output image.

It is a second object of the present invention to make it possible to obtain an output image having a

20   good gradation reproducibility and high quality.

A second aspect of the present invention is the image processing method for preparing the look-up table for converting the input color signal into the output color signal constituted by a plurality of color

25   components which are used when the color output apparatus outputs a color image, which is a method for setting up a lattice point between the vertex showing

the chromatic color and the vertex showing the black in

the reproducible color space of the above described

color output apparatus, wherein a space between the

vertex showing the above described chromatic color and

5   the vertex showing the black is divided into a

plurality of areas different in the combination of the

color component used in the above described color

reproduction, and the lattice point is set up according

to a ratio of the above described each area between the

10   vertex showing the chromatic color and the vertex

showing the black.

Other objects and features of the present

invention will be apparent from the following

description and accompanying drawings.

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BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a diagram showing a relationship between

look-up table lattice points for reproducing an output

color space and a color space of a color printing

20   apparatus;

FIG. 2 is a flowchart illustrating a first

processing;

FIG. 3 is a flowchart illustrating a second

processing;

25   FIG. 4 is a flowchart illustrating a third

processing;

FIG. 5 is a diagram illustrating resultant

examples of the first and the second processing;

FIG. 6 is a diagram illustrating the resultant example of the third processing;

FIG. 7 is a diagram illustrating a comparison result of a reproduction color space in a color printing apparatus which is shown by the axis of the ordinates L*, the axis of abscissas chroma (chromaticness) when a parameter for calculating a complementary color ink and a chromatic color ink is changed in the present embodiment;

FIG. 8 is a diagram illustrating the comparison result of the reproduction color space in the color printing apparatus which is shown by the axis of the ordinates b*, the axis of abscissas a* when the parameter for finding the complementary color ink and the chromatic color ink is changed in the present embodiment;

FIG. 9 is a flowchart illustrating a flow of the first processing in a second embodiment;

FIG. 10 is a flowchart illustrating the flow of the second processing in the second embodiment;

FIG. 11 is a flowchart illustrating the flow of the third processing in the second embodiment;

FIG. 12 is a flowchart illustrating the flow of the fourth processing in the second embodiment;

FIG. 13 is a diagram illustrating examples of the results of the first and the second processing;

FIG. 14 is a diagram illustrating the example of the result of the third processing in the second embodiment;

FIG. 15 is a diagram illustrating the comparison result regarding the reproduction color space in the color printing apparatus shown by the axis of the ordinates L*, the axis of abscissas chroma (chromaticness) when the parameter for finding the complementary color ink and the chromatic color ink is changed in the second embodiment; and

FIG. 16 is a diagram illustrating the comparison result regarding the reproduction color space in the color printing apparatus shown by the axis of the ordinates b*, the axis of abscissas a* when the parameter for finding the complementary color ink and the chromatic color ink is changed in the second embodiment.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

First Embodiment

In a color printing apparatus with an input signal taken as a RGB three primary color signal and an output ink as CMYK, a preparation method of a color conversion LUT (look-up table) for converting a RGB signal into a CMYK signal will be described.

In the present embodiment, an output color space of a color printing apparatus is assumed as shown in

FIG. 1 and the color conversion LUT is taken as having each output color corresponding to an input RGB signal value. The input RGB signal is constituted by 8 bits data for each color (0 to 255) and the color conversion

5   LUT is taken as having 16 lattice point intervals and 17 lattice point numbers.

The preparation of the color conversion LUT will be performed by the following procedure.

First, a LUT lattice point, W (paper white),

10   RGBCMY and a processing black BK in the vertex of a reproducible color space of the color printing apparatus are decided, and an output constitutional ink color in each lattice point is decided.

Next, a constitutional ink color of each LUT

15   lattice point in a W (paper white)- RGBCMY and a RGBCMY- Bk lines is decided.

From the above two procedures, the most outer contour of the reproducible output color space of the color printing apparatus is decided.

20   The constitutional ink color in each LUT lattice point column in the W (paper white) - BK line is decided.

By using the constitutional ink color of an arbitrary LUT lattice point column in the most outer

25   contour and the constitutional ink color of the lattice point column in the W (paper white) - Bk line, an interpolation processing is performed, so that an

output of the arbitrary LUT internal lattice point is decided.

In the present embodiment, the K ink amount and the under color removal amount is controlled, so that

5   the following effects can be obtained.

(1) Graininess is not produced in high lightness area.

(2) Color reproducible range of the color printing apparatus is utilized as much as possible.

10   (3) Continuity of a black gradation is maintained.

A method for preparing a lattice point data of the color conversion LUT by controlling the K ink amount and the under color removal amount, that is, a method for deciding the constitutional ink color of each LUT

15   lattice point in the RGBCMY - BK line will be described below. Particularly, it is important to decide the constitutional ink in the lattice point on the line which links R, G, B, C, M, Y and K.

As a representative example, the decision of the

20   constitutional ink in the output LUT lattice point column from R (red) to BK (process black) will be described below with reference to the flowcharts as shown in FIG. 2, FIG. 3, and FIG. 4. Note that the decision of the constitutional ink amount from other

25   respective colors of G, B, C, M, and Y to the process black can be decided in the similar procedure.

A group of lattice points on a chromatic color -

non-chromatic color line linking R (red) and Bk

(process black) as shown in FIG. 1 is defined as a

processing object lattice point column.

Based on the constitution of each light ink of the

5   CMYK, a R - Bk line is divided into the area (the Area

0, FIG. 5) defined by a chromatic color ink and a

complementary color ink amount (the K ink amount = 0),

the area (the Area 1) defined by the chromatic color

ink and the complementary color ink amount and the K

10   ink amount and the area (the Area 2) defined by the

chromatic color ink and the K ink (the complementary

color ink amount = 0).

First Processing

The CMYK ink amount deciding method in the area

15   (the Area 0)defined by the chromatic color ink and the

complementary color ink amount will be described with

reference to FIG. 2. In the first processing, the K

ink amount is decided so that the graininess in the

output image attributable to the K ink dot is

20   controlled.

First, attention is given to the graininess

attributable to the K ink dot in an input start of the

K ink, and the maximum complementary ink amount (the

maximum amount of a gray component ink) in each

25   chromatic color ink of the CMYRGB to be visually

indistinguishable in this graininess is defined in

advance. Further, a CMYK total ink placing amount

limit condition Vlim is defined in advance, and the maximum value of the chromatic color ink amount which satisfies the total ink placing amount limit condition is defined. The maximum value of the chromatic color

5   ink amount is equivalent to a vertex color in the LUT.

In the above described lines, the complementary color ink amount is smaller than the chromatic color ink amount. Therefore, the complementary color ink amount indicates a gray component. Therefore, in the

10   present embodiment, the complementary color ink amount is also referred to as a gray component ink amount.

Here, a cyan ink amount (a gray ink amount) which is equivalent to the complementary color ink of a chromatic color R ink is taken as Cg. The chromatic

15   color R ink is constituted by a Y ink and a M ink.

In step 201, the cyan ink amount Cg is defined as 0.

In step 202, the chromatic color R ink amount Rg is defined as the maximum value Rm of the chromatic

20   color R ink amount.

In step 203, the cyan ink amount Cg and an ink placing amount V in the chromatic color R ink amount Rg are calculated. Here, since the chromatic color R ink is constituted by the Y ink and the M ink, in step 203,

25   the ink placing amount V is calculated by adding the cyan ink amount Cg, the Y ink amount and the M ink amount which constitute the chromatic color ink amount

Rg.

In step 204, the ink placing amount V calculated by step 203 is compared with the CMYK total ink placing amount limit condition Vlim in the color printing

5   apparatus and it is determined whether the ink placing amount V is equal to or less than the ink placing amount limit condition Vlim.

When the ink placing amount V is equal to or less than the ink placing amount limit condition Vlim, in

10   step 206, an ink combination of the chromatic color R ink amount Rg and the cyan ink amount Cg is maintained.

In step 207, the cyan ink amount Cg is incremented.

In step 208, until it is determined that the cyan

15   ink amount Cg becomes the above defined maximum complementary color ink amount Cm, the processing subsequent to step 202 is repeated.

In step 204, when the ink placing amount V is equal to or larger than the ink placing amount limit

20   condition Vlim, in step 205, the chromatic color R ink amount is decremented. By using the chromatic color R ink amount Rg reduced by decrement, the processing subsequent to step 203 is performed.

When the ink combination maintained in step 206 is

25   plotted in order, it becomes like the Area 0 in the graph as shown in FIG. 5

Second Processing

Next, the CMYK ink deciding method, which is performed as the second processing, in the area defined by the chromatic color ink, the complementary color ink and the K ink and the area defined by the chromatic color ink and the K ink (the complementary color ink amount = 0) will be described with reference to FIG. 3.

In step 301, a complementary color cyan ink amount is defined as Ck= Cglim. This is intended for not causing a discontinuity in the boundary with the Area 0.

In step 302, the chromatic color R ink amount Rk is defined as the maximum value Rm of the chromatic color R ink amount.

In step 303, the K ink amount is defined as k = 0.

Subsequently, the K ink is linearly increased to the K ink amount maximum value (γ = 1).

On the other hand, the chromatic color R ink amount Rk is defined by the maximum value Rm of the chromatic color R ink amount and an equation (3.1) having a γr parameter.

$$R k = R m \cdot (1 - (K / 2 5 5)^{\gamma r}) \quad ...(3.1)$$

While the complementary cyan ink amount Ck is, similar to the chromatic color R ink amount Rk, also defined by the maximum value Cglim of the complementary color cyan ink amount and γc parameter, a zero value (an end) in the complementary color ink for the value of the K ink is defined by an arbitrary parameter

limit. Therefore, the complementary color cyan ink amount Ck is defined by an equation (3.2).

$$C_k = C_g \lim \cdot (1 - F_{col}(K, \gamma_c, \lim)) \quad \ldots(3.2)$$

In step 304, the cyan ink amount Ck is defined by using the K ink amount K by the above described equation (3.2).

In a stop 305, the chromatic color R ink amount Rk is defined by the above described equation (3.1).

In step 306, the ink placing amount V is calculated in the K ink amount K, the cyan ink amount Ck calculated by step 304 and the chromatic color R ink amount Rk calculated by step 305.

In step 307, the ink placing amount V calculated by step 306 is compared with the CMYK total ink placing limit condition Vlim in the color printing apparatus and it is determined whether the ink placing amount V is equal to or less than the CMYK total ink placing amount limit condition Vlim.

When the ink placing amount V is equal to or less than the CMYK total ink placing limit condition Vlim, in step 309, the ink combination of the K ink amount K, the cyan ink amount Ck and the chromatic color R ink amount Rk is maintained.

In step 310, the K ink amount K is incremented.

In step 311, until it is determined that the K ink amount K becomes the maximum ink amount, the processing subsequent to step 304 is repeated.

In step 307, when the ink placing amount V is equal to or larger than the CMYK total ink placing amount limit condition Vlim, in step 308, the chromatic color R ink amount Rk is reduced until it satisfies the condition.

The resultant examples in the flowchart processing as shown in FIG. 3 become like the Area 1, the Area 2 of the graph as shown in FIG. 5.

As shown in the Area 2, since the chromatic color ink amount is gradually reduced to the last and the K ink amount is increased, the continuity of a black gradation can be maintained.

From each ink amount of the CMYK calculated by the flowchart processing of the foregoing FIG. 2, FIG. 3, the ink combination of the ink of the arbitrary point number is selected and a batch by the ink combination selected by the color printing apparatus is outputted and color-measured.

The resultant examples are shown in FIG. 7, FIG. 8.

In FIG. 7, FIG. 8, regarding the cyan ink amount Ck defined by the equation (3.2) and the chromatic color R ink amount Rk defined by the above described equation (3.2), the result of the change made in three types for each parameter in the equation (3.1), the equation (3.2) is shown.

As evident from FIG. 7, FIG. 8, regarding the area

defined by the chromatic color ink and the complementary color ink amount (K = 0), the area defined by the chromatic color ink and the complementary color ink amount and the K ink and the

5   area defined by the chromatic color ink and the K ink (the complementary color ink amount = 0), the reproduction color space is the maximum and each parameter in the equation (3.1) and the equation (3.2) for smoothly linking each area can be concentratedly

10 decided.

In this way, each parameter in the equation (3.1) and the equation (3.2) for smoothly linking area defined by the chromatic color ink and the complementary color ink amount, the area defined by the

15 chromatic color ink and the complementary color ink amount and the K ink and the area defined by the chromatic color ink and the K ink (the complementary color ink amount = 0), where the reproducible color space is the maximum and gradation is high, is decided.

20 Third Processing

Based on each ink of the CMYK in each decided parameter, the batch printed by the ink combination of the selected arbitrary point number is formed, and the batch is color-measured, and a three dimensional

25 coordinate value is calculated in the interior of the color reproduction space.

The processing for defining the CMYK ink amount on

the LUT lattice point will be described with reference
to the flowchart as shown in FIG. 4.

In step 401, each ink amount of the CMYK of
arbitrary number N points on R-Bk and each three
5 dimensional coordinate in the interior of the color
reproduction space are defined. On this occasion, a
boundary point of each area of Area 0, Area 1 and Area
2 as shown in FIG. 5 is included in the arbitrary
number N points.

10 In step 402, a Bk point is taken as a starting
point 0 and a three dimensional distance is defined as
L (0)= 0.

In step 403, a three dimensional distance of a
point n from an adjacent point (n - 1) is calculated.
15 When the three dimensional space is a Lab space, it is
calculated by the following equation:

$$L(n) = \sqrt{(L^*(n)-L^*(n-1))^2+(a^*(n)-a^*(n-1))^2+(b^*(n)-b^*(n-1))^2}$$

In step 404, the Bk point is taken as the starting
point and a distance L(R) to R is calculated as a total
20 sum of the three dimensional distances between each
point calculated in step 403.

$$L(R) = \Sigma L(n) \quad (n=0 \cdots N)$$

In step 405, a distance L(G) of the area (the Area
0) defined by the chromatic color ink and the
25 complementary ink amount is calculated and a ratio for
the distance L(R) is calculated.

In step 406, a distance L(GK) of the area (the

Area 1) defined by the chromatic color ink and the complementary ink amount and the K ink is calculated, and a ratio for the distance L(R) is calculated.

In step 407, a distance L(BK)of the area (the Area 2) defined by the chromatic color ink and the K ink (the complementary color ink amount = 0) is calculated, and a ratio for the distance L(R)is calculated.

In step 408, according to a ratio of the distances between each area and the distance L(R), the lattice point number between each area in the R-Bk lattice point column of the color conversion LUT is distributed and a boundary lattice point is defined.

In step 409, for the LUT lattice point which becomes a boundary of each area, the CMYK ink amount which becomes the boundary of each area is defined.

In step 410, the distance defined as each area is equally divided by the number of lattice point intervals, and the distance between the LUT lattice points in each area is calculated.

In step 411, in the R - Bk lattice point column, with the BK as the starting point, an object LUT lattice point is defined as a lattice point which is shifted to the R side by one lattice point from a BkLUT lattice point.

In step 412, the distance between lattice points from the starting point Bk in the object LUT lattice point is calculated from the distance between the LUT

lattice points in each area calculated in step 410.

In step 413, from the combination of the CMYK ink defined in step 401 and each distance from the starting point Bk, which holds in-between the distance between the lattice points from the starting point Bk in the defined object LUT lattice point, the CMYK ink amount in the object LUT lattice point is calculated by a linear interpolation processing based on the distance.

In step 414, the object lattice point is shifted to the R side by one lattice point.

In step 415, in all the lattice points in the R - Bk lattice point column, until each ink amount of the CMYK is defined, the processing of step 412 to step 415 is repeated.

One example of the results of the above described processing is shown in FIG. 6.

In this way, by performing the first to the third processing as shown in the flowcharts as illustrated in FIG. 2 to FIG. 4, the K ink amount and the under color removal amount can be fairly controlled, so that the graininess in the area where lightness is high is controlled, a color reproducible range is utilized at the maximum and a gradation reproducibility can be enhanced.

Second Embodiment

The preparation method of a color conversion LUT (look-up table) for converting a device RGB into an

output ink corresponding color signal in a multi-color printing apparatus using a CMYK dark ink and a diluted light ink at least for one color as an output ink will be described.

5   The preparation of the color conversion LUT will be performed by the following procedure.

First, an arbitrary lattice point for outputting a LUT lattice point, W (paper white), RGBCMY and a processing black Bk in the vertex of a reproducible
10   color space of a color printing apparatus is decided, and an output constitutional ink color in each lattice point is decided.

Next, the constitutional ink color of each LUT lattice point in W (paper white)- RGBCMY and RGBCMY -
15   Bk lines is decided.

From the above two procedures, the most outer contour of the reproducible output color space of the color printing apparatus is decided.

The constitutional ink color in each LUT lattice
20   point in the W (paper white)- Bk line is decided.

By using the constitutional ink color of the arbitrary LUT lattice point column in the most outer contour and the constitutional ink color of the lattice point column in the W (paper white)- Bk line, an
25   interpolation processing is performed, and an output of the arbitrary LUT internal lattice point is decided.

In the present embodiment, the K ink amount and

the under color removal amount are controlled, so that the following effects can be obtained.

(1) Graininess is not produced in high lightness area.

5   (2) Color reproducible range of the color printing apparatus is utilized as much as possible.

(3) Continuity of a gradation is maintained.

A method for preparing a lattice point data of the color conversion LUT by controlling the K ink amount 10 and the under color removal amount, that is, a method for deciding the constitutional ink color of each LUT lattice point in the RGBCMY - Bk line will be described below. It is particularly important to decide the constitutional ink in the lattice point on the line 15 which links R, G, B, C, M, Y and K.

As a representative example, the decision of the constitutional ink in the output LUT lattice point column from R (red) to a process black will be described below with reference to the flowcharts as 20 shown in FIG. 9, FIG. 10, FIG. 11. Note that the decision of the constitutional ink amount from each color of the GBCMY to the process black can be decided by the similar procedure.

A group of lattice points on a chromatic color - 25 non-chromatic color line linking R (red) and Bk (process black) as shown in FIG. 1 is defined as a processing object lattice point column.

Based on the constitution of each dark and light ink constitution of the CMYK, each LUT lattice point column linking R - Bk is divided into the area (the area 0, FIG. 15) defined by the chromatic color ink and the complementary light ink amount, the area (the Area 1) defined the chromatic color ink and the complementary dark and light ink amount, the area (the Area 2) defined by the chromatic color ink and the complementary color dark ink amount, the area (the Area 3) defined by the chromatic color ink and the complementary dark ink amount and the K ink and the area (the Area 4) defined by the chromatic color ink and the K ink (the complementary dark ink amount = 0).

(First Processing)

A CMYK ink amount deciding method in the area defined by the chromatic color ink and the complementary color light ink amount will be described with reference to the flowchart as shown in FIG. 9.

Attention is given to the graininess attributable to the K ink dot, and the maximum complementary color dark ink amount which becomes visually indistinguishable, a total ink placing amount limit condition Vlim in the color printing apparatus and the chromatic color ink amount which satisfies the total ink placing amount limit condition are defined in advance.

Further, regarding each chromatic color ink of the

CMYRGB, attention is given to the graininess attributable to the complementary color dark ink dot at the start of input of the complementary color dark ink, and the maximum complementary color light ink amount in

5 which this graininess becomes visually indistinguishable and the chromatic color ink amount which satisfies the total ink placing amount limit condition in the color printing apparatus shall be defined in advance.

10 For the chromatic color R ink which is constituted by an arbitrary Y dark ink amount and M dark ink amount, a light cyan ink amount CI which is a complementary light ink amount is defined.

In the above described lines, the complementary

15 color ink amount is smaller than the chromatic color ink amount. Therefore, the complementary color ink amount denotes a gray component. Therefore, in the present embodiment, the complementary color ink amount is referred to as a gray component ink amount.

20 The maximum value Rm of the chromatic color R ink amount realizes R which is a vertex point color in the LUT.

In step 1201, the light cyan ink amount is defined as CI = 0.

25 In step 1202, the chromatic color R ink amount Rg is defined as the maximum value Rm of the chromatic color R ink amount.

In step 1203, the light cyan ink amount CI and an ink placing amount V in the chromatic color R ink amount Rg are calculated.

In step 1204, the ink placing amount V in step 1203 is compared with the total ink placing amount limit condition Vlim in the color printing apparatus.

When the condition is satisfied, in step 1206, an ink combination of the chromatic color R ink amount Rg in the light cyan ink amount CI is maintained.

In step 1207, the light cyan ink amount CI is incremented.

In step 1208, until it is determined that the light cyan ink amount CI becomes the maximum complementary color light ink amount CIm, the processing subsequent to step 1202 is repeated.

In step 1204, when the condition is not satisfied, in step 1205, the chromatic color R ink amount Rg is reduced until the condition is satisfied.

The resultant example of the flowchart processing as illustrated in FIG. 9 becomes like the Area 0 of a graph as shown in FIG. 13.

(Second Processing)

A CMYK ink amount deciding method in the areas (the area 1, the area 2, FIG. 15) defined by the chromatic color ink and the complementary color dark and light ink amount will be described with reference to the flowchart as shown in FIG. 10.

For the chromatic color R ink constituted by an arbitrary Y dark ink amount and M dark ink amount, the cyan ink amount Cr which is the complementary dark ink amount and the cyan ink amount CI which is the

5   complementary light ink amount are defined.

In step 1301, the complementary light cyan ink amount is defined as CI = CIm.

In step 1302, the complementary dark ink amount is defined as Cr = 0.

10   In step 1303, the chromatic color R ink amount Rg is defined as the maximum value Rm of the chromatic color R ink amount.

Subsequently, the complementary dark ink amount is linearly increased until it reaches the complementary

15   dark ink amount maximum value Crm.

While the complementary color light cyan ink amount CI is defined by the maximum value CIlim of the complementary cyan ink amount and a γ1 parameter, a zero value (an end)in the complementary ink is defined

20   by an arbitrary parameter Iimit L for the complementary color dark ink amount. Therefore, the complementary color light cyan ink amount Cl is defined by the following equation.

$$C I = C I lim \cdot (1 - F l i (C r, \gamma l, limit L)) \cdots \quad (13.1)$$

25   In step 1304, the light cyan ink amount CI is defined by the above described equation (13.1).

In step 1305, the ink placing amount V in the

light cyan ink amount CI, the dark cyan ink amount Cr and the chromatic color R ink amount Rg is calculated.

In step 1306, the ink placing amount V in step 1305 is compared with the total ink placing amount limit condition Vlim in the color printing apparatus.

When the condition is satisfied, in step 1308, the ink combination of the light cyan ink amount CI, the dark cyan ink amount Cr and the chromatic color R ink amount Rg is maintained.

In step 1309, the dark cyan ink amount Cr is incremented.

In step 1310, until it is determined that the dark cyan ink amount Cr becomes the maximum dark cyan ink amount Crm, the processing subsequent to step 1303 is repeated.

In step 1306, when the condition is not satisfied, in step 1307, the chromatic color R ink amount Rg is reduced until it satisfies the condition.

The resultant examples in the flowchart processing as shown in FIG. 10 become like the Area 1, the Area 2 of the graph as shown in FIG. 13.

(Third Processing)

A CMYK dark and light ink amount deciding method in the area defined by the chromatic color ink, the complementary color dark ink amount and the K ink and the area defined by the chromatic color ink and the K ink (the complementary dark ink amount = 0) will be

described with reference to the flowchart of FIG. 11.

In step 1401, the complementary color dark cyan ink amount is defined as Cr = Crm.

In step 1402, the chromatic color R ink amount Rk is defined as the maximum value Rm of the chromatic color R ink amount.

In step 1403, the K ink amount is defined as k =0.

Subsequently, the K ink is linearly increased to the K ink maximum value.

On the other hand, the chromatic color R ink amount Rk is defined by the following equation having the maximum value Rm of the chromatic color R ink amount, the K ink amount K and the γr parameter.

$$R k = R m \cdot (1 - (K / 2 5 5) \gamma r) \cdots \quad (14.1)$$

The complementary color dark cyan ink amount Cr is defined by the following equation having the maximum value Crm of the complementary color cyan ink amount, a γc parameter and a parameter limit R showing the zero value (the end) of the complementary color ink.

$$C r = C r m \cdot (1 - F r (K, \gamma c, l i m i t R)) \cdots \quad (14.2)$$

In step 1404, the dark cyan ink amount Cr is defined by the K ink amount K and the above described equation (14.2).

In step 1405, the chromatic color R ink amount Rk is defined by the above described equation (14.1).

In step 1406, the ink placing amount V is calculated by the K ink amount K, the dark cyan ink

amount Cr and the chromatic color R ink amount Rk.

In step 1407, the ink placing amount V in step 1404 is compared with the CMYK total ink placing amount limit condition Vlim in the color printing apparatus.

When the condition is satisfied, in step 1409, the ink combination of the chromatic color R ink amount Rk in the K ink amount K and the cyan ink amount Cr is maintained.

In step 1410, the K ink amount K is incremented.

In step 1411, until it is determined that the K ink amount K becomes the maximum K ink amount, the processing subsequent to step 1404 is repeated.

In step 1407, when the condition is not satisfied, in step 1408, the chromatic color R ink amount Rk is decreased until it satisfies the condition.

The resultant examples in the flowchart as shown in FIG. 11 become like the Area 3 and the Area 4 as illustrated in the graph shown in FIG. 13.

From the ink amount combination calculated by the flowchart processing of FIG. 9 to FIG. 11, which have defined each dark and light ink amount of the CMYK, the ink combination of the arbitrary point number is selected, so that the batch in the ink combination of the above described selected ink combination by the color printing apparatus is outputted and color-measured.

The resultant examples are shown in FIG. 15, FIG.

16.

In FIG. 15, FIG. 16, regarding the light cyan ink amount CI and the dark cyan ink amount Cr to be defined by the above described equation (13.1) and the above described equation (14.2), the result of the change made in three types of each parameter in the above described equation (13.1), the above described equation (14.1) and the above described equation (14.2) is shown.

Therefore, as evident from FIG. 15, FIG. 16, regarding the area defined by the chromatic color ink and the complementary color light ink amount, the area defined by the chromatic color ink and the complementary color dark and light ink amount, the area defined by the chromatic color ink and the complementary color dark ink amount, the area defined by the chromatic color ink and the complementary color dark ink amount and the K ink and the area defined by the chromatic color ink and the K ink (the complementary color ink amount = 0), the reproducible color space is the maximum and each parameter for smoothly linking each area in the above descried equation (13.1), the above described equation (14.1) and the above described equation (14.2) can be concentratedly decided.

Therefore, each parameter, where the reproducible color space is the maximum and the gradation is high,

for smoothly linking each area in the above described
equation (13.1), the above described equation (14.1),
the above described equation (14.2) can be decided.
(Fourth Processing)

5   In each dark and light ink amount of the CMYK in
each decided parameter, regarding the ink combination
of the selected arbitrary point number, by forming and
color-measuring the batch, each three dimensional
coordinate value in the color reproducible space is

10   calculated.

A processing for defining each dark and light ink
amount of the CMYK in the LUT lattice point based on
the each dark and light ink amount of the CMYK in each
parameter decided by the above described procedure will

15   be described with reference to the flowchart shown in
FIG. 12.

In step 1501, regarding the arbitrary number N
point on R - Bk in the color conversion LUT, the three-
dimensional coordinate value in each ink amount of the

20   CMYK and the color reproducible space is defined. On
this occasion, each dark and light ink amount of the
CMYK in the boundaries of the Area 0, the Area 1, the
Area 2, the Area 3 and the Area 4 is included in N
point.

25   In step 1502, a Bk point is taken as a starting
point 0 and a three dimensional distance L is defined
as $L(0) = 0$.

In step 1503, for the above described arbitrary number of points n, the three dimensional distances L from adjacent points (n - 1) are calculated respectively.

5 When the three dimensional space is a Lab space, it can be calculated by the following equation.

$$L(n) = \sqrt{(L^*(n)-L^*(n-1))^2+(a^*(n)-a^*(n-1))^2+(b^*(n)-b^*(n-1))^2}$$

In step 1504, the Bk point is taken as the starting point, and the distance L (R) to R is 10 calculated as a total sum of the three dimensional distances between respective points calculated in step 1503.

$$L(R) = \Sigma L(n) \quad (n=0 \cdots N)$$

In step 1505, from each three dimensional 15 coordinate value in the color reproducible space, the distance L(GI) of the area 0 is calculated, and a ratio for the distance L(R) is calculated.

In step 1506, the distance L(GIr) of the Area 1 is calculated, and a ratio for the distance L(R)is 20 calculated.

In step 1507, the distance L(Gr) of the Area 2 is calculated, and a ratio for the distance L(R) is calculated.

In step 1508, the distance L(GK) of the Area 3 is 25 calculated, and a ratio for the distance L(R) is calculated.

In step 1509, the distance L(BK) of the Area 4 is

calculated, and a ratio for the distance L(R) is calculated.

In step 1510, according to a ratio of the distance of each area and the distance L(R), the LUT lattice point number reproducing each area distance is distributed.

In step 1511, for the LUT lattice point which becomes the boundary of each area, the CMYK dark and light ink amount which becomes the boundary of each area is defined.

In step 1512, the distances L(GI), L(GIr), L(Gr), L(GK) and L(BK) which are defined as the distances between each area are equally divided by the distributed lattice point number and the distance between the LUT lattice point between each area is calculated.

In step 1513, in the R - Bk lattice point column, with Bk as a starting point, the object LUT lattice point is defined as a lattice point shifted from the BkLUT lattice point to the R side by one lattice point.

In step 1514, the distance between the lattice points from the starting point Bk in the object LUT lattice point is obtained from the distance between the LUT lattice points in each area obtained in step 1512.

In step 1515, based on the combination of each dark and light ink amount of the CMYK which holds the distance between each lattice points from the starting

point Bk in the defined object LUT lattice point and
each distance from the starting point Bk defined in
step 1515, each dark and light ink amount of the CMYK
in the object LUT lattice point is calculated from a
5   linear interpolation processing based on the distance.

In step 1516, the object lattice point is shifted
to the R side by one lattice point.

In step 1517, in all the lattice points in the R -
Bk lattice point column, until each dark and light ink
10   amount of the CMYK is defined, the processing from step
1514 to step 1517 is repeated.

As described above, by performing the processing
by the flowchart as shown in FIG. 9 to FIG. 12,
regarding the defined LUT lattice point column, the
15   output reproducible color space of the color printing
apparatus becomes as maximum as possible, and the
preparation of the color conversion look-up table for
realizing a good gradation reproducible image output is
realized.

20   The resultant examples of the processing by the
flowchart as shown from FIG. 9 to FIG. 12 are shown in
FIG. 14.

According to the present embodiment, by the first
processing, no graininess can be produced in the high
25   lightness area. Further, by the first to the third
processing, the color reproducible range of the color
printing apparatus can be utilized to the full. Also,

by the first to the fourth processing, a continuity of
the color can be maintained.

Third Embodiment

It is evident that the above described each

5   embodiment can adapt the present invention not only in
the preparation of the color conversion look-up table
used in the interior of the color printing apparatus,
but also in the preparation of the look-up table used
in the color conversion in a host computer in the

10   system such as transmitting an image output result
treated with a color conversion processing to the color
printing apparatus in the interior of the host computer
connected to the color printing apparatus.

To the computer inside the apparatus or the system

15   connected to the various devices so that the various
devices can be operated to realize the functions of the
above described embodiment, the program code of a
software for realizing the above described embodiment
functions are provided, and those functions practiced

20   by operating the above described various devices
according to the program stored in the computer (CPU or
MPU) of the system or the apparatus are also included
in the category of the present invention.

In this case, the program code itself of the above

25   described software realizes the above described
functions of the embodiment, and the program code
itself and means for providing the program code to the

computer, for example, a storage medium which has stored such a program constitute the present invention.

As the storage medium storing such a program code, for example, a floppy disk, a hard disk, an optical

5   disk, an optical magnetic disk, CD-ROM, a magnetic tape, a non-volatile memory card, ROM and the like can be used.

Needless to mention, by practicing the provided program code by the computer, not only the above

10   described functions of the embodiment can be realized, but also such a program code is included in the embodiments of the present invention even when the above described functions of the embodiment in collaboration with an OS (an operation system), in

15   which the program code is operated, or another application soft and the like are realized.

Needless to mention, after the provided program code is stored in a function expansion board of the computer or a memory provided in a function expansion

20   unit of the computer, in the case where a CPU and the like provided in the function expansion board or the function storage unit perform a part or the whole of an actual processing based on the instruction of the program code, and the above described functions of the

25   embodiment are realized by the processing, such a case is also included in the present invention.

While the present invention has been described

with respect to what is presently considered to be the preferred embodiments, it is to be understood that the invention is not limited to the disclosed embodiments. To the contrary, the present invention is intended to

5   cover the various modifications and equivalent arrangements included within the spirit and scope of the appended claims.